TEST PLAN GUIDANCE

MIXED WASTE FOCUS AREA

JULY 19, 1996

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LIST OF FIGURES

1. INTRODUCTION

Graduated Requirements and Expectations for Test Plans at Each Stage of Research and Development are described

Test plans are an integral part of the chain of documentation used by the Mixed Waste Focus Area (MWFA) to direct and manage transition of mixed waste treatment technologies through a series of defined development stages. These development stages, with a description of the types of data required are:

Stage 1: Basic Research. Basic research is not within the scope of the MWFA. Therefore test plan requirements are not delineated in this guidance document.

Stage 2: Applied Research. Experiments and data should be sufficient to validate the technical approach or concept and demonstrate its potential applicability to an identified MWFA need. Data quality objectives tend to be rudimentary but adequate to establish technology applicability.

Stage 3: Exploratory Development. Experiments focus on detailed technical issues (process versatility and flexibility, safety, environmental releases, secondary wastes, etc.) that affect the feasibility of technology implementation. Experiments should demonstrate that the technology is a significant improvement over existing technology. Data quality objectives are more detailed, cover all issues, and may require supporting statistical analyses.

Stage 4: Advanced Development. Experiments focus on demonstrating operation of integrated systems. Data requirements are developed in concert with the anticipated end-user. Data are gathered to address process capacity and efficiency, siting, permitting, manufacturing, ES&H, and RAM issues. Data quality objectives are stringent, statistically based, and generate data requirements for precision, accuracy, representativeness, completeness, and comparability.

Stage 5: Engineering Development. Experiments must yield all information needed to a) provide full and detailed design criteria and specifications including material specifications and radiological partitioning information, b) provide all scaling factors, such that a commercial system can be confidently sized, c) ensure that all critical process interfaces are tested and satisfied, d)support detailed capital and operating cost estimates for the entire facility, e) obtain all data required for permitting, f) demonstrate satisfactory performance for all non-standard components, and g) provide data to meet monitoring and control requirements. Again, data requirements are developed in concert with the anticipated end-user.

Scope of Test Plans. Test plans must be prepared by the cognizant principal investigator (PI) for experiments and tests conducted during development stages two through five above. The required level of detail and adherence to guidance document

requirements will depend on the stage of technology development, the scope of specific test series, and the level of effort of the test program. It is difficult to exactly define the level of detail to be expected for each section of the plan, for all types of technologies, at each stage of development. Therefore, the appropriate level of detail in the test plan must be negotiated and agreement reached between the PI and the cognizant Waste Type Manager, or other MWFA designee in advance of preparation of the test plan. While the test plan must be sufficiently detailed to allow technical review and to support the level of effort planned, preparation of the test plan should not consume a significant fraction of the resources available for the test program.

Other MWFA documents used to manage technology development include:

- Technical Development Requirements Documents (TDRD)
- Technical Task Plans (TTP)
- Technology Development Plans (TDP)
- Market Analyses
- Stakeholder Plans
- Test Results
- Technology Performance Reports

Additional information concerning technology development transition criteria and documentation may be found in the draft "Mixed Waste Focus Area Technology Development and Transitions Guidance", Owens, et. al., April 30, 1996.

A flowchart showing the relationship of these documents is shown in Figure 1.

Other documents, e.g. NEPA, safety analyses, QA/QC plans, detailed run plans, operating procedures, permits, etc. may be required for a particular test program. These should be referenced where appropriate, but should not be extensively reproduced in the test plan. When reference is made to a test plan supporting document, e.g. QA plan, operating procedure, chemical analysis plan, they should be readily available to any test plan reviewer designated by the MWFA.

Approvals and Changes. Test plans shall be approved by the cognizant WTM. If, during the experimental period, it becomes necessary to make significant changes to the planned experiments, those changes and the revised test plan shall be reviewed and approved by the WTM. Reasons for significant changes might include:

- Program funding or guidance changes,
- Dropping a major segment of the test parameter range due to poor behavior or incipient failure of experimental apparatus,
- Unexpectedly rapid equipment failure such as due to fatigue, corrosion or erosion,
- Early indication of failure to achieve improved performance expected from the technology.

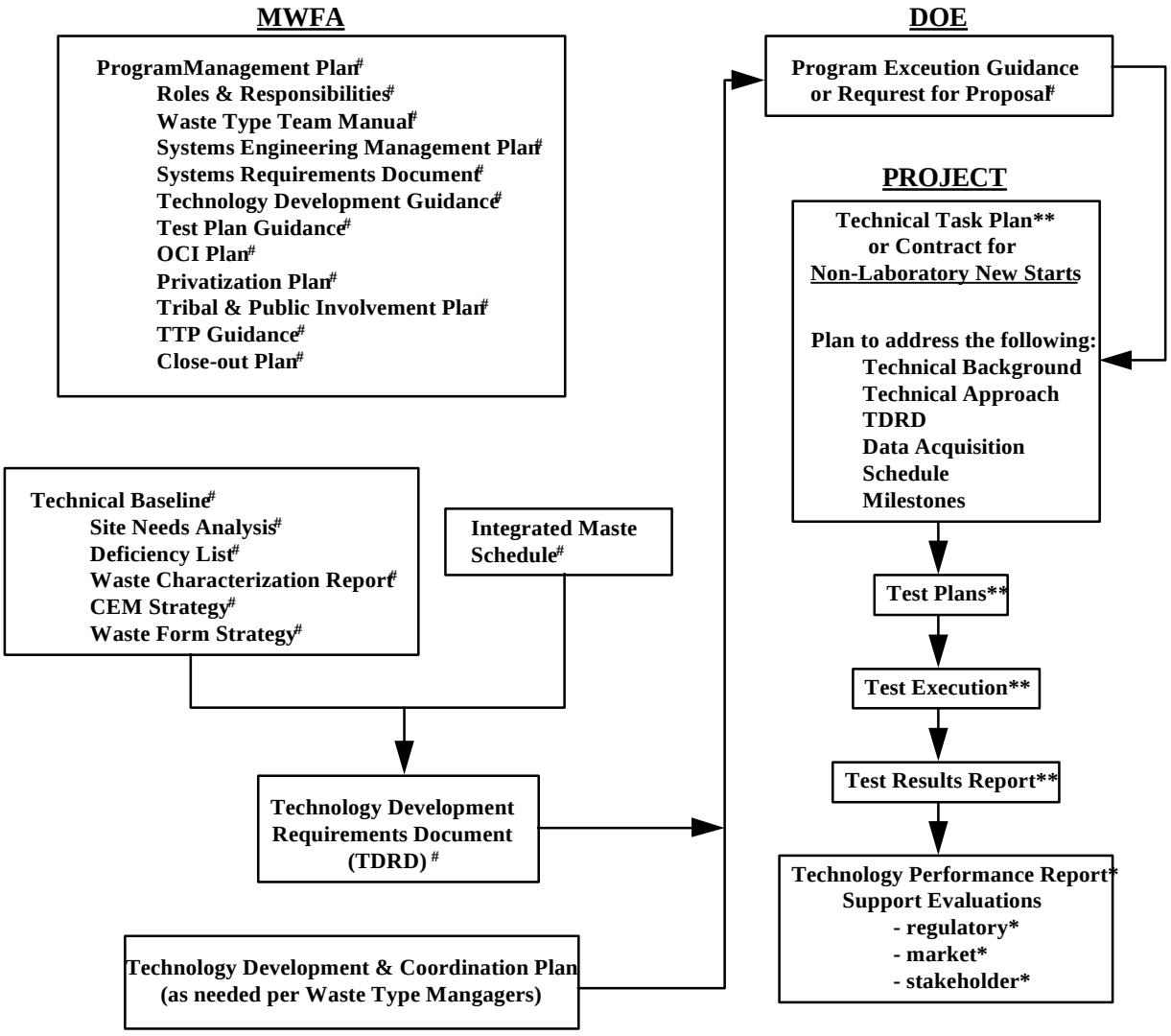

Figure 1. Flow of MWFA Documentation

2. STANDARDIZED CONTENTS FOR TEST PLANS

General Standardized Contents for Test Plans are Described.

The MWFA has generated a standardized table of contents for test plans. The required level of detail and adherence to guidance document requirements will depend on the stage of technology development, the scope of a specific test series, and the level of effort of the test program.

Below is the table of contents for the test plan. It is followed by a description of the contents of each section in the test plan. Where appropriate, examples are given to further clarify contents of specific sections.

TECHNOLOGY DEVELOPMENT TEST PLAN
TABLE OF CONTENTS

C. Instrumentation, Process Monitoring, and Control Design

VIII. **Run Plan Summary**
A. Operations Plan
B. Data Acquisition and Sampling Plan

IX. **Data Analysis**

X. **Support Requirements**

Figure 2. Standardized Table of Contents for Technology Development Test Plan

Summary

The test plan summary should briefly describe the program context, the technical content of the test plan, and what is to be achieved by the planned experiments. The key contents to be summarized should include:

- Necessary background information (technology concept and function plus potential applications),
- Test objectives,
- Types of tests or experiments planned,
- Number and duration of experiments planned,
- Key data to be gathered,
- Facilities to be used, and
- Anticipated test results.

A description should be provided of the key decisions which will be made based on the results of the tests.

Background

The background section should provide detailed program context and technical background for the test plan as supported by liberal reference to other relevant program and technical documents.

Statement of mixed waste treatment need. A statement of the specific need within the MWFA that is to be addressed by the technology should be provided in sufficient detail that it will be clear how the test plan will answer all or part of that need. The statement of the need must reference the relevant Technology Development Requirements Document (TDRD).

Technology concept and function. A description of the concept and practice of the technology should be given in adequate detail that it is clear what this technology is, how it works, and how it differs from competitive technologies. The theoretical basis of the technology should be provided.

For example, for a treatment technology, important information concerning the following should be provided:

- thermodynamics,
- reaction kinetics,
- key materials of construction
- mass transport and mixing,
- waste feed treatment, and
- nature of treated materials and process products.

Information should be sufficiently detailed to clearly convey the current level of understanding of the science and engineering of the proposed technology. It may be necessary to refer to separate reports, which contain the detailed descriptions of the physical and theoretical bases for the technology. However, even with the use of outside references, the discussions provided in the test plan must be adequately detailed to support selection of parameters to be tested and test ranges for those parameters.

Current status or stage of development. Describe how the technology will be applied to address a specific need within the MWFA. A conceptual block flow diagram or actual process flow diagram (PFD) with overall material balances and key process conditions should be provided to support the test plan. This PFD should clearly show the key process unit operations, location of process instrumentation for monitoring, and

instrumentation for data gathering. Interactions with upstream and downstream unit operations should be identified. If the test is of a single component or unit operation, its interactions and interfaces with other system elements should be described.

For a treatment technology, interactions of particular interest include:

- container handling and opening,
- sorting and removal of unacceptable matrices, and
- feed size reduction and preconditioning.

For monitoring or control technologies interactions of interest include:

- process conditions and sample conditioning
- limiting range of parameters of interest,
- interferences, temperature, pressure, humidity variations,
- flowrate and flow regime (turbulent vs. Laminar), and
- sample representativeness

Needed technology improvements. This section should describe and explain improvements in the performance of the candidate technology that will be required before the technology can achieve adequate treatment or performance levels. All aspects of the technology that require improvement should be summarized even if some of these aspects are not to be tested under this Test plan. Needs will typically include:

- range of response, precision, and accuracy for monitors,
- process effectiveness parameters, such as increased reaction rates at readily controlled conditions,
- specific throughput for a given reactor, and
- extent of reaction, conversion, destruction, separation, removal, purification, or stabilization.

Testing the effectiveness of alternative process equipment designs and configurations must be supported by the technical justification for the expected improvement in performance. Equipment improvements may involve:

- extending the range of process operations
- feed and discharge mechanisms and equipment
- behavior and handling of secondary streams

Finally, compare the anticipated stage of development at the close of the planned tests with the overall needed improvements. As shown in Figure 3, answer the question: "What portion of the needed development will be accomplished by these tests?"

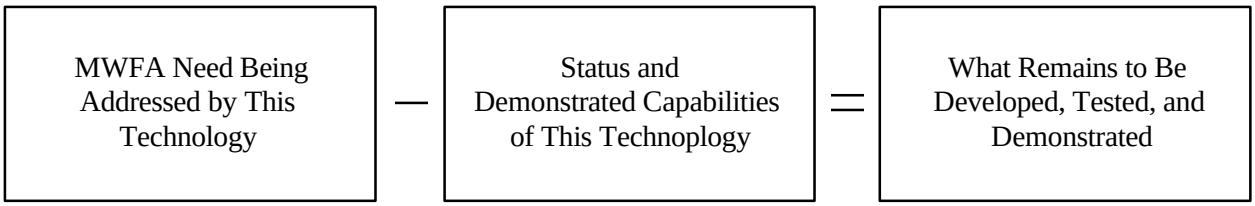

Figure 3. Justification for the Test Program

Required Data and Acquisition Approach

Improvements needed to successfully deploy the technology were described in the previous section. In this section, describe exactly what data will be obtained during the test and how it will be obtained. Measurements, observations, and data acquisition needed to evaluate improvements being addressed by this test plan should also be described. Statements concerning needed improvement in performance must be converted to measurable and quantifiable parameters as set forth in the applicable TDRD.

Explain how the missing required information will be obtained through the test program. Briefly discuss potential alternative ways of obtaining the needed data and justify the approach selected.

State clearly whether this set of experiments will answer all remaining questions to complete technology development. If not, describe the technology stage of development which will have been achieved after completion of the test.

Details of experimental design, equipment design, data acquisition and data analyses will be described in following sections of this test plan. Only summary information needed to justify the data acquisition approach should be presented here.

Test Objectives

Test objectives are derived from the decisions to be made, uncertainties to be resolved, and data gaps to be filled. Test objectives should be specific, narrowly focused, measurable, independent of test results, and contain implicit success criteria. One or more specific technical objectives must be clearly stated for each test or experiment. In addition, each technical objective must have associated data quality objectives (DQOs).

Implicit, assumed, or supplemental criteria for evaluating each objective's successful attainment must be made explicit.

Test objectives should not be confused with expected results and should be stated in a manner that allows a successful test even if the data generated indicate an unfavorable result.

Test objectives should focus on generation of information and data to support or establish:

- process and equipment design to meet pre-established performance criteria,

- implementation and reliable operation of the technology in radioactive service, and/or
- basis for obtaining regulatory approval of new technologies or requests for variances and requirements for operating permits.

Test objectives should be prioritized and identified as either "critical" or "non-critical," as shown in Figure 4. Critical objectives are key to the decisions to be made based on the results obtained and normally require gathering of quantitative data. Quality assurance and quality control (QA/QC) requirements for critical objectives are typically more stringent.

Noncritical objectives require gathering of information and data which are useful for evaluating, or improving the understanding of technology performance, but which do not directly bear on key decisions to be made based on the tests. Non-critical objectives often are satisfied using subjective evaluations and qualitative data. QA/QC requirements for noncritical objectives are typically less demanding.

Test objectives should be specific and detailed. Vague abstractions such as "to demonstrate, to examine, to investigate, to evaluate, to determine, etc." are not appropriate when used alone to define a test objective. These terms must be supported by language showing exactly "what and how". The following is an example of a poor test objective that is vague and not quantifiable.

To investigate and determine the partitioning and deposition of semivolatile fission products in the off-gas.

A good test objective is one that is subject to measurement and verification and allows a successful test even if the data generated indicate an unfavorable result as shown below:

To obtain off-gas partitioning and mass balance data for key semivolatile fission products (Cs, Ru, Tc) as a function of primary chamber outlet temperature, exhaust gas flowrate, and exhaust gas oxidizing conditions.

In general, there are three classes of test objectives: design data objectives, operating data objectives and regulatory strategy data objectives.

Design Data Objectives: Design data objectives address design, improvement, scale-up, and integration of specific processes, systems. equipment, and components. Design test objectives focus on generating needed design data including information pertaining to heat, momentum, and mass transport; thermodynamics, reaction kinetics, materials of construction, mass and energy balances, materials handling, etc.

Operating data objectives: Operating data objectives address work which leads to a more complete understanding of the technology through experience in operating and maintaining equipment or systems. Operating test objectives should focus on obtaining data to support preliminary safety and hazards and operations (HAZOPS) analyses and on providing reliability, availability, and maintainability (RAM) data suitable for evaluating the technology's potential for application in radioactive service. These concerns may be more difficult to satisfy in a radioactive

environment than in a typical industrial application.

Operating objectives for "demonstration" tests should be specified in detail including waste feed description, planned processing rate(s), key operating parameters (temperature, pressure, concentration, power density, velocity, etc.), duration of tests and description of expected product(s). Demonstration test objectives must be developed in collaboratively with a probable end user.

Objectives should include recording and analysis of all accidents, operating limitation, process excursions, and process equipment failures. Likewise, operating objectives should include providing descriptions and analyses of methods or techniques employed for accident mitigation, process recovery and equipment repair and maintenance following upset or failure.

Regulatory Strategy Data Objectives: Regulatory strategy data objectives address work to better define the technology and its impact on the environment. Test objectives should focus on obtaining data to support permitting and other regulatory requirements.

For compliance with an existing regulatory requirement, the data quality objective may be easily included in the statement of the test technical objective as in the example below.

Determine, at a 95% confidence level, if leachable mercury in amalgamation product is below 0.20 mg/l based on TCLP testing.

Some DOE wastes may not be treatable by an acceptable or BDAT technology or be treatable to an established concentration standard by any available technology. For preparation of requests for approval of a new technology, establishing the basis for a variance, or establishing the basis for an alternative treatment standard, the test objectives will be defined to provide appropriate data to support the application for regulatory approval.

Data Quality Objectives

Each test objective should be supported by simple data quality objectives (DQOs). DQOs define the statistical measures (confidence intervals, error limits, test power, etc.) of data quality that are used to ensure that collected data are appropriate to support project requirements and decisions as described in the technical test objectives (See Figure 5). DQOs provide the rationale and bases for experimental design, instrumentation design, data acquisition design, sampling, analyses, and detailed run plans.

DQOs for large and complex tests should be developed using a formalized procedure including:

- formulation of problem statement,
- definition of the decision to be made and inputs to the decision,
- establishment of decision rules and tolerable limits on decision errors, and
- optimization of the test and data gathering design.

DQOs for smaller component tests or bench-scale studies may be developed

more subjectively and may be more qualitative in nature.

However, regardless of the size of the project, DQOs require answers to the following questions:

- What types of data are needed?
- How many data points of each type are enough?
- Which data are mandatory and which are only desired?
- Which data must be verified, validated, duplicated, or subjected to statistical analyses, and how will it be done?
- Which data address which defined information needs, and are input to key decisions?
- Will the data and supporting documentation meet the quality requirements of cognizant regulatory agencies?

An example data quality objective to accompany the previous example of a technical test objective might be:

> Data acquisition and analyses will be performed in a manner to ensure that error bars on the mass balance results do not exceed plus or minus 20% of the reported values at a confidence level of 90 percent.

In many cases the test and data quality objectives may be more qualitative and presented together in a single statement:

> Determine the corrosion rate of Monel in fresh reagent by daily measurements (mass to 1 mg) of immersed coupons over a period of three months.

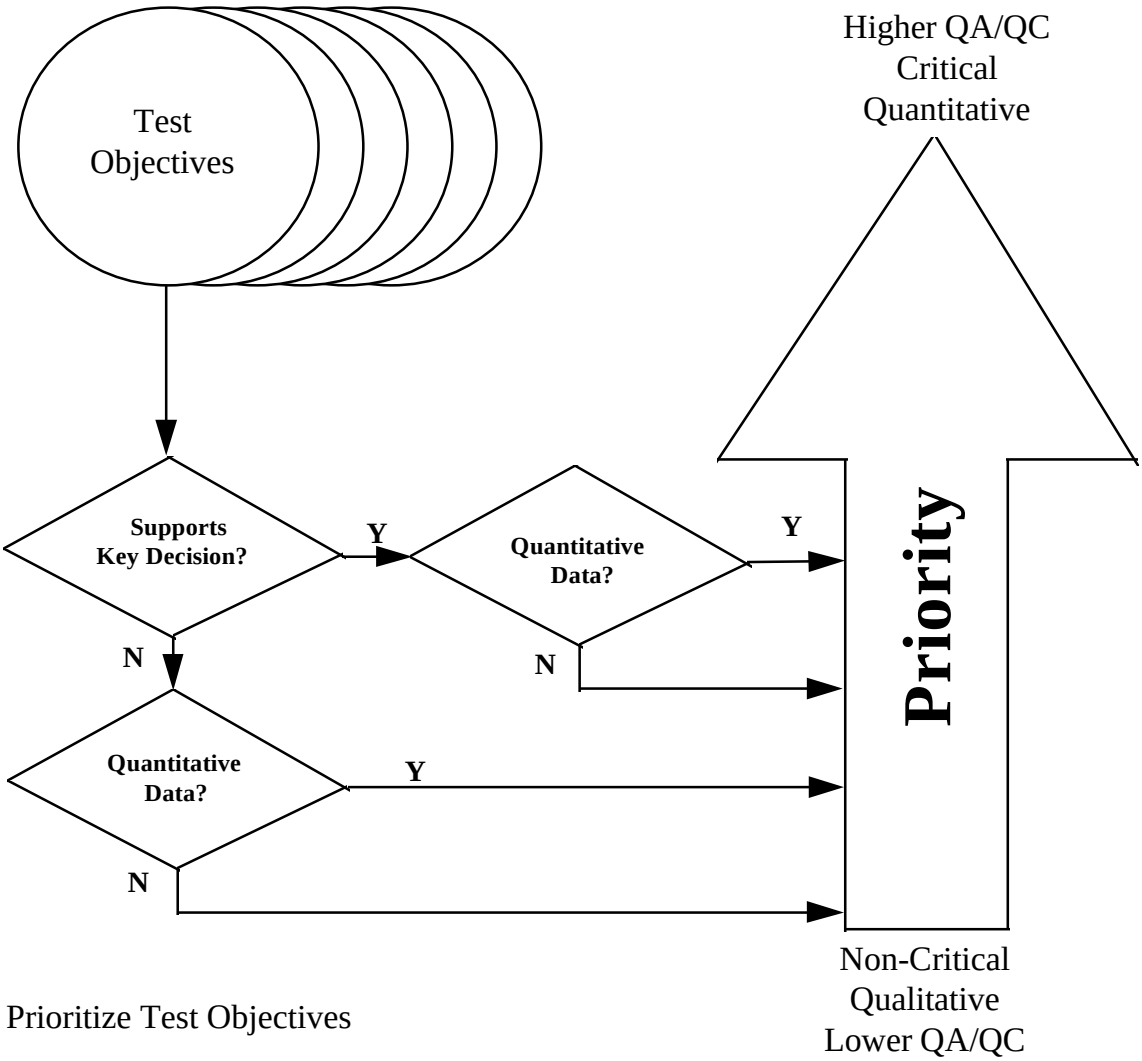

Figure 4. Critical Data is Gathered to Support Key Decisions

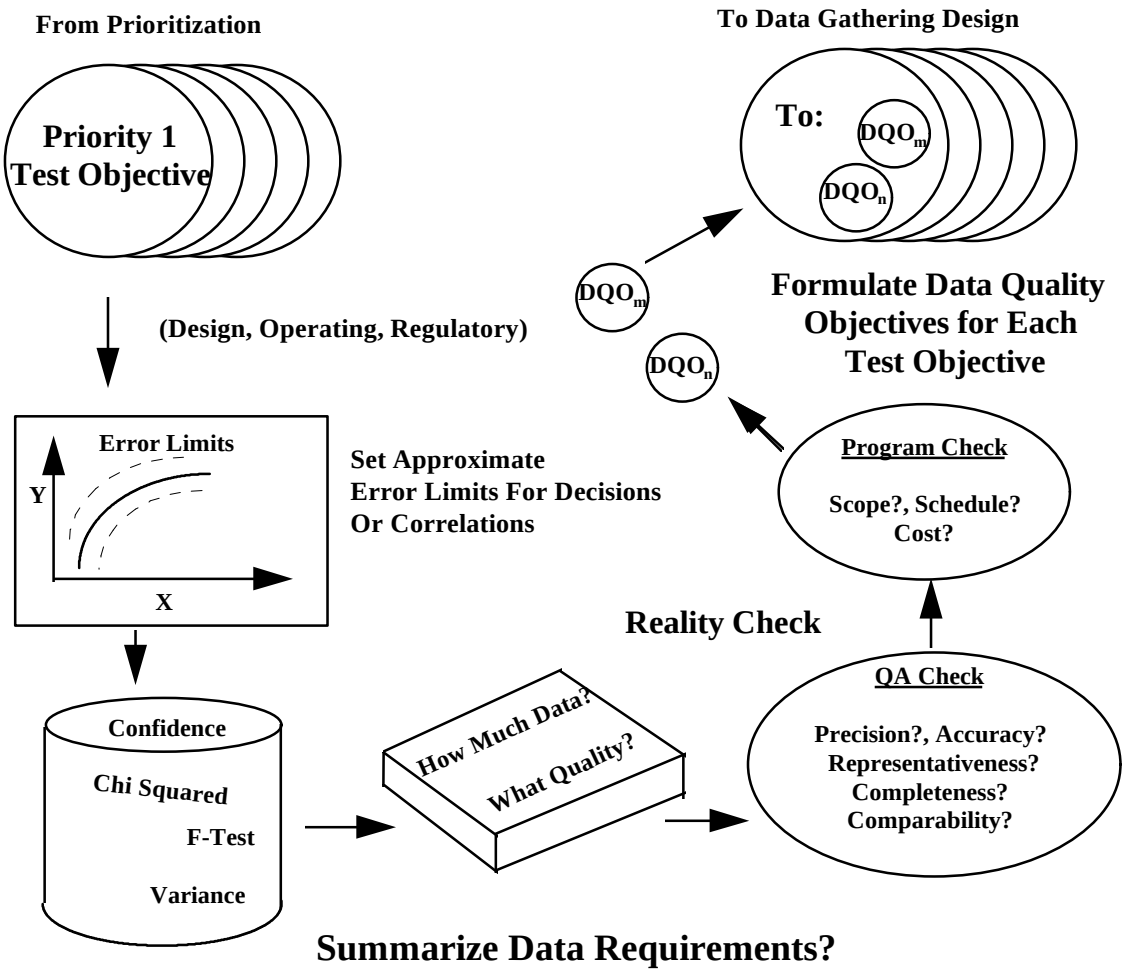

Figure 5. Data Quality Objectives Accompany Each Technical Objective

Data Acquisition Design

This section should demonstrate that the PI has a detailed plan for obtaining all data needed to meet the test objectives and that the data gathered will be of appropriate quality.

The test and data quality objectives are used to generate specific test data requirements, which determine or influence the design of the test experiments, equipment, instrumentation, and controls. This is shown in Figure 6.

Describe the strategy and integrated plan for ensuring sufficient and appropriate data are gathered and that the aforementioned data quality objectives are attained.

Although they are closely tied, Data Acquisition Design is presented ahead of the Experimental Design to reinforce the fact that the major reason to conduct a test or experiment is to acquire needed data. Too often, equipment is fabricated first and is then inadequate to allow generation of the required data.

In reality all test design functions are conducted in an iterative process wherein information from each design function is used in other design functions to optimize the entire test program.

Specific data requirements must be formulated from the defined test and data quality objectives. This process requires:

Identification of point data sets. Point data sets are those measurements and analyses from a single process location (thermocouple, flow meter, sample tap, etc.), or which characterize a single process parameter (differential pressure, concentration gradient, etc.).

For the example test objective:

> To obtain off-gas train partitioning and mass balance data for key semivolatile fission products (Cs, Ru, Tc) as a function of primary chamber outlet temperature, exhaust gas flowrate, and exhaust gas oxidizing conditions

a partial set of the required point data sets for a wet off-gas system might include:

> - Primary combustion chamber outlet temperature
> - Exhaust gas volume flow rate
> - Exhaust gas oxygen concentration
> - Mass of Cs, Ru, Tc deposited in piping between primary and secondary combustion chambers

Point data sets should be listed for each test objective. These lists are generated to ensure that all data needs are anticipated. Lists for different test objectives may contain one or more of the same identified point data sets. For example, the point data set for "primary combustion chamber outlet temperature" may serve to meet the data requirements for more than one test objective, and therefore will appear more than one time.

Specifications for obtaining data for each point data set. For each required point data set, specify the anticipated method or technique for obtaining the data set. Specifications for the above example might be:

> - Exhaust gas temperature: thermocouple and strip chart recorder
> - Exhaust gas volume flow rate: annubar, pressure transducer, and data logger
> - Exhaust gas oxygen concentration: in-situ zirconia probe and data logger
> - Mass Cs deposited in piping: NaI detector, in-situ gamma scan

Formulation of data quality requirements for each point data set. Based on the data quality objectives discussed above, data quality requirements must be developed. Data quality requirements typically include

- Number of tests
- Frequency of data measurements
- Frequency and method of calibration
- Traceability of standards
- Levels of precision and accuracy
- Repeatability
- Document control

Preparation of data requirements package for each test technical objective. The data requirements packages typically will specify:

- frequency of scanning and logging for instruments,
- frequency of sampling and total number of samples required for sampling and analysis systems,
- instrumentation calibration requirements including means and frequency,
- specification of standard or published methods for sampling and analyses,
- requirements for traceability of standards,
- requirements for precision, accuracy, and repeatability for measurements and analytical methods, and
- requirements for data handling, chain-of-custody.

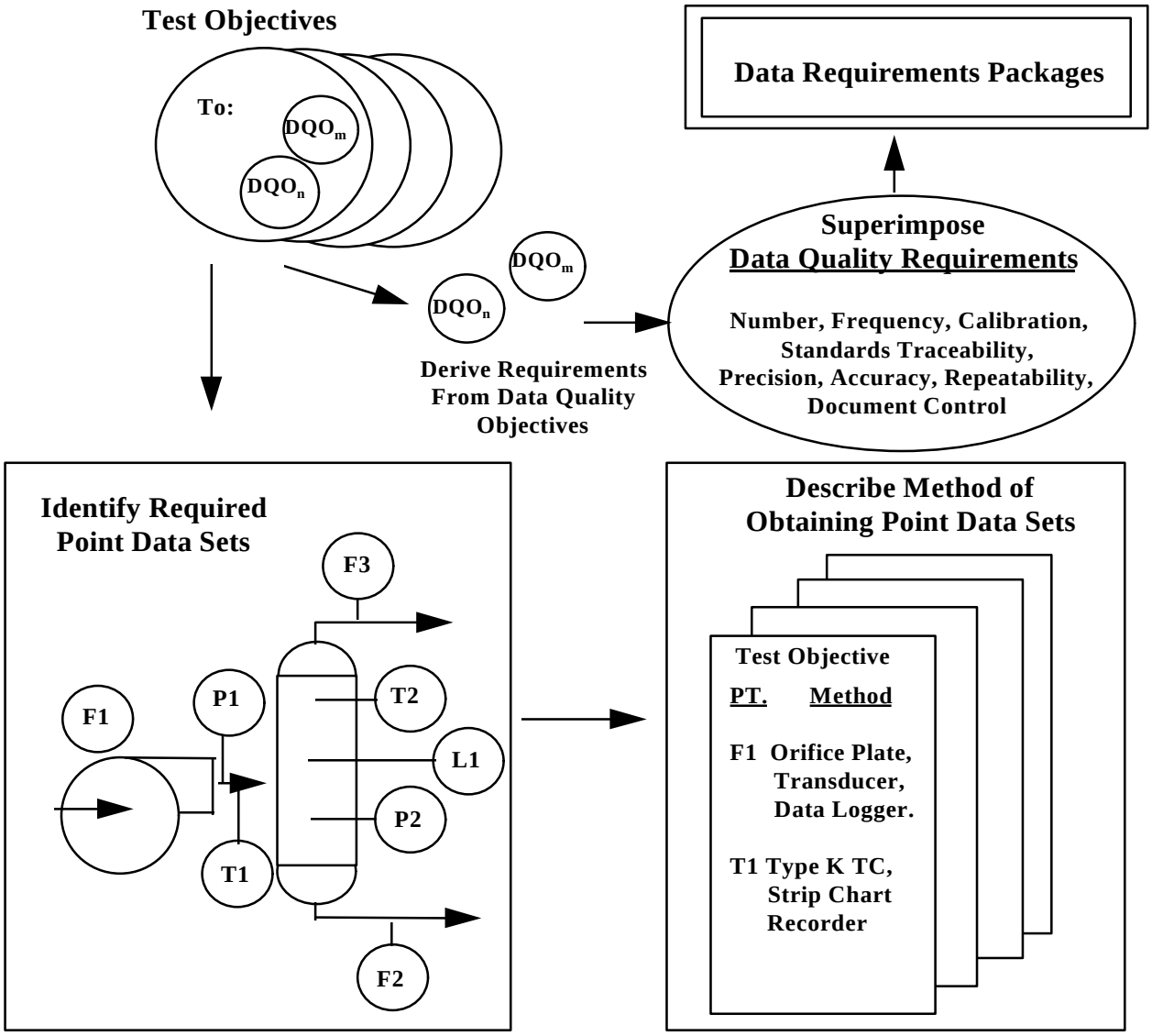

Figure 6. Data Acquisition Design Produces a Data Requirements Package for Each Test Objective

Design of Experiments

Experimental design. Proper experiment design ensures that all needed data are acquired efficiently, safely, and cost effectively with minimum environmental impact and generation of secondary wastes or experiment residuals. As shown in Figure 7, more than one experiment may be needed to satisfy the data requirements for certain test objectives. Conversely, certain single experiments may satisfy the data requirements of more than one test objective.

For each test objective, one or more experiments or test runs must be designed and executed to obtain the needed data. The method by which the data needs discussed above will be fulfilled by specific experiments or test runs must be described.

The design of the experiments should focus on the data quality objectives and statistical requirements. Details of the sequence and mechanics of run execution should be presented under "Run Plan Summary" below.

If necessary, check with the MWFA to obtain assistance with regulatory analysis tasks.

Experiments should be designed to learn the most with the fewest tests and measurements. Measure the right things, in the right way, and understand what is being measured. Experiments must also be designed to minimize environmental releases and minimize generation of wastes, particularly mixed waste, radioactive, or hazardous. Used experimental equipment can become waste.

Individual experiments or runs should be described in terms of their predominant design features, as shown in the following four examples:

Extended duration (500 hr) demonstration run to collect enumeration data on frequency of failure of torch components, zirconia probe, and off-gas sintered metal filter.

Standard 3 by 3 factorial parametric test to characterize mercury concentration change in scrub solution as a function of secondary combustion chamber temperature, quench water flow rate, and scrubber solution pH.

Component optimization test to tune quench water controller and verify maximum deviation of the off-gas temperature not more than 3 C from the set point 130 C when the secondary chamber operating temperature moves over the full range of 200-1600 C.

System safety test to demonstrate automated "hot restart" after a simulated power failure. Key safety concern is generation of combustible or explosive gas mixtures in the off-gas treatment train.

Data to be gathered for each experiment should be listed together with any applicable QA requirements for:

- Precision
- Accuracy
- Completeness

- Representativeness
- Comparability.

Where specific QA requirements apply, include a brief statement of how they will be addressed by the experimental design. Use of non-standard analytical methods; or standardization and calibration bases should be explained and justified. Likewise, unique or particularly expensive analytical work should be identified and justified in terms of importance of the data. Four examples of specific QA requirements are shown below:

All wet chemical analyses will be performed according to approved EPA standard methods (Reference List) and instruments will be calibrated using standards traceable to the National Bureau of Standards.

Based on precision and accuracy data provided by the Method 5 Train manufacturer, a minimum of 30 isokinetic sample measurements will be required to achieve the 95 percent confidence level for off-gas particulate concentration determination. At least 35 measurement will be taken at steady state for each parameter variation in order to ensure a complete data set.

During the parametric testing, independent process control variables will not be allowed to vary more than plus or minus 3 percent during data gathering to ensure comparability of data. Operations will be deemed to be at steady state when all independent variables have remained within the plus or minus 3 percent limit for a period of at least 10 minutes.

Not fewer than 10% of the samples sent to the contract laboratory will be "blank" or "spiked" samples prepared by our laboratory. Samples will be packaged, identified, and submitted for analysis in a manner to ensure "double blind" testing.

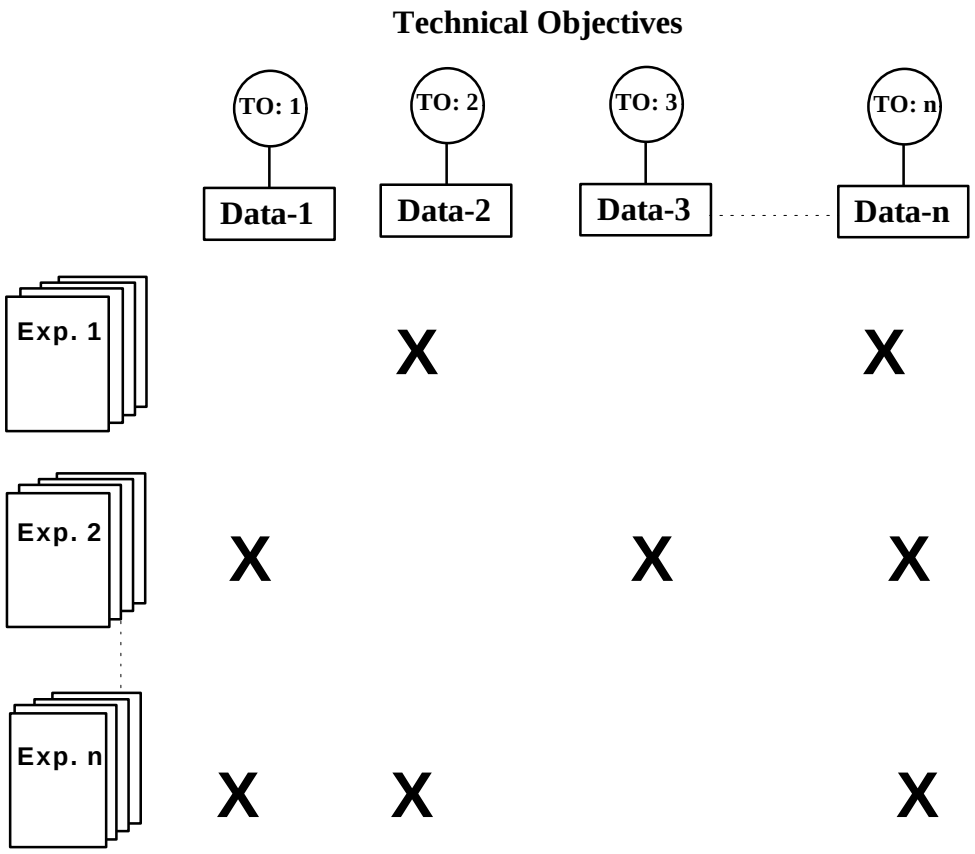

Figure 7. Design Experiments to Efficiently Acquire All Needed Data

Equipment Design. Descriptions of the experimental equipment must be provided in enough detail so that the mode of operation and likelihood of success may be evaluated. Unit operations and equipment sizes, capacities, throughputs, process conditions, interfaces, and limits should be described in detail.

Drawings and diagrams should provide two levels of detail:

- Overall equipment arrangement and process flow diagram (PFD), and

- Details of each key piece of equipment.

The PFD should be accompanied by an appropriate process flowsheet (PFS) providing overall process conditions plus mass and energy balance data sufficient to support the planned testing. Clearly describe which operations are integrated and continuous and which may be separated by process surge, feed adjustment, or storage units. Drawings of key equipment should be accompanied by descriptions of materials of construction, performance limitations, process conditions, physical/chemical reactions, steady state behavior, potential transients and upsets, plus any safety concerns.

Key equipment drawings should indicate locations and methods for instrument

measurement and sampling needed for process monitoring and control plus experimental data acquisition. Details of the integrated instrumentation, process monitoring and control design should be presented in the following section.

For component tests, the test stand plus auxiliary and support systems should be described in sufficient detail to demonstrate that realistic tests will be conducted. Limitations of the experimental setup or test stand, when compared to full plant scale processing, should be described together with a discussion of how the experimental results will be extrapolated to an understanding of the next level of development.

Test stands for full scale component demonstrations must be shown to simulate process conditions adequately to allow evaluation of interactions of the component with anticipated plant unit operations.

Instrumentation, process monitoring and control design data. Detailed descriptions of the capabilities and anticipated uses for all instrumentation, equipment, and systems that will be used during the tests for process monitoring, process control, and/or experimental data acquisition should be provided.

Provide instrument lists identifying all instruments and sampling/analysis equipment and describing their locations, capabilities, and interfaces. Use sketches with adequate detail to make clear the location of the sampling or monitoring point. Show that the sampling point will allow measurement of the parameter of interest. Where appropriate, refer to drawings presented in "Equipment Design" above.

Describe all equipment used for signal conditioning, automatic data logging, and process control. Describe modes of control and data acquisition for all test phases -- startup, steady state, upsets, shutdown, etc. Identify and describe instrumentation and control equipment having safety functions.

Describe which measurements are to be used for operating control of the system and which will be used for derivation of process parameters.

Run Plan Summary

Summarize the logical sequence of operations and data acquisition activities for each experiment or run included in the test plan

Operations Plan. Descriptions of test runs and data acquisition activities should be brief and to the point including only that level of detail necessary to convey an understanding of the purpose and complexity of each run and the relationship of each run to others in a sequence.

Define the purpose of each run and reference the appropriate test and data quality objectives. Descriptions provided here should not include the step-by-step instructions contained in detailed run plans. Provide enough information that the reader can follow the experimental runs and understand their purpose, the parameter ranges tested, and the sampling and data gathering points used.

Describe the kinds of wastes or simulated wastes and range of characteristics of waste

feed materials to be tested. Describe any planned waste characterization. Explain what is to be measured, why this run is the best way to make the measurement, and what improvement in technology or understanding will result. Define the range of operating conditions to be tested. Justify the range of test conditions selected, and explain the value to the program test objectives.

Collection of reliability, availability, and maintainability (RAM) data at every opportunity is important to the ultimate successful application of any technology. Consideration should be made here to those pieces and segments of the experimental setup which are representative enough of expected plant equipment and operating conditions to provide some RAM information. In any case, all process upsets, excursions, blockages, equipment failures, or any other interruptions or off-normal conditions should be reported and analyzed.

If some or all of the runs are intended as "system tests" the setup must be representative of a significant part of the final prototypical system. Experiments in such systems must include gathering process stability, repeatability, and RAM data.

Describe and justify any changes in equipment combinations, configuration, or ordering of process steps between runs. It must be made clear what changes, if any, are planned in equipment and or conditions between the various experimental runs. Explain provisions for adjustment of planned runs if results from initial or scoping tests are different than expected in this plan. Address the conditions or observations that would cause the aborting at any point of the remaining portions of the runs. Changes or adjustments anticipated in the beginning would not be considered "significant" changes to the run plan as discussed above in Section 2, "Test Plan Scope & Contents".

Data Acquisition And Sampling Plan. Provide a detailed data acquisition and sampling plan for each run as shown in Figure 8. Suggested format is a matrix table of all measurement, sampling, and analysis points vs. test sequences (startup, parameter steady states, transitions, shutdown, etc.) with the intersections marked symbolically to indicate the type, number, and frequency of measurements made or samples taken. Measurement and sampling points should be keyed to drawings furnished previously.

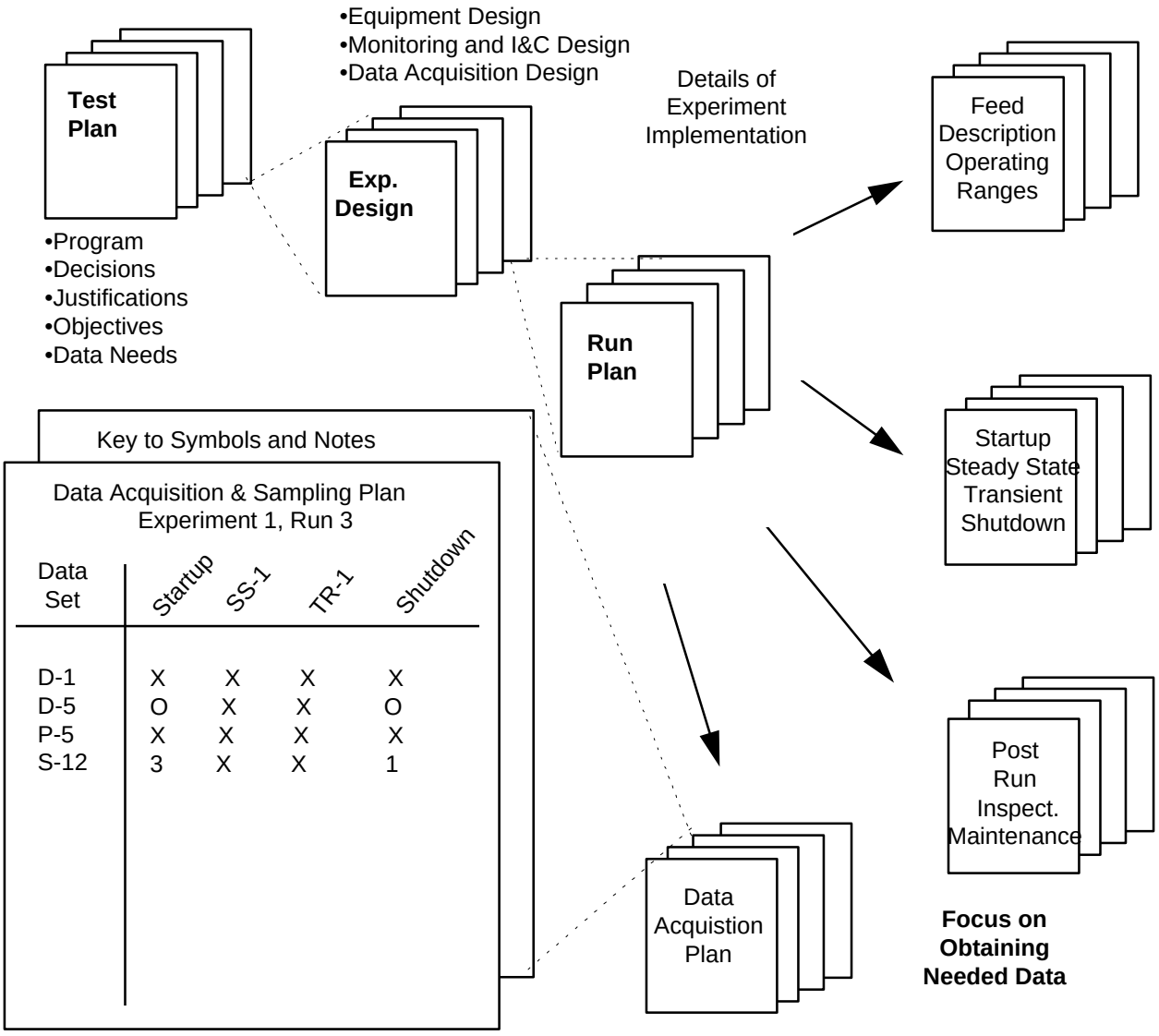

Figure 8. All Needed Data for Each Experiment are Summarized in Detailed Data Acquisition and Sampling Plan

Data Analysis

Provide a complete explanation of the plan for data reduction and analyses together with a detailed description of how the test data are to be converted into the process parameters of interest. Explain the rationale and derivation of performance correlations from the experiment design together with the use of these correlations to enhance the understanding of the process.

Show correlations of performance parameters with process conditions, e.g. independent variables (temperature, pressure, feed composition, feed rate, etc.) vs. dependent variables (reaction efficiency, fractional conversion, off-

gas composition, product characteristics, waste generation, etc.). Address normal and off-normal conditions of operation.

Provide example calculations to illustrate correlations and anticipated data reduction techniques. Calculations should show the information content of all observed data as projected by the investigators. Provide the basis for conversion of all data and analytical measurements to process parameters of interest. Describe the nature and format of the final test data compilations. Show that all useful information is gathered.

Show that collected data can be used to evaluate the repeatability of operating conditions vs. system performance. Repeatability is a primary consideration in the ultimate demonstration of a technology that is reliable and deployable. Data analyses must show that the technology can be taken to a given set of operating conditions and that the performance of the process will then be reproduced from run to run.

Support Requirements

Logistics and provisions for adequate facilities, staff, test materials, residuals disposal, and decommissioning are essential to successful testing. Show that all support requirements have been considered. Demonstrate understanding of the entire scope and complexity of the test program.

Briefly describe the site and facilities to be used for the tests. Identify the operating and any support staff required. Describe how, where, and by whom all sample analyses will be performed, e.g. principal investigator, facility laboratory, EPA certified contract laboratory. Describe methods and logistics (packaging, mode of transport, chain of custody, etc.) for submitting samples.

Describe materials, chemical, and utility requirements for the tests together with appropriate supply logistics. Identify criteria and procedures for any special acceptance testing or required characterization.

Describe provisions for management and disposal of test wastes, by-products, or residuals. Describe provisions for facility decontamination, decommissioning, and equipment disposal.

3. CONCLUDING REMARKS

In its technology development program, the MWFA requires a certain degree of commonality in experimental tests are planned and conducted. The driver for experimental testing is the data needs specified by an end use customer. These needs dictate particular experiments, which in turn lead to particular equipment designs. To aid in this process, this document has been prepared to provide guidance in the development of standardized test plans.

All test plans developed under MWFA funding must be submitted for review by appropriate Waste Type Managers and their designees. Also, where appropriate, all work will be developed collaboratively with other EM-50 focus areas and crosscutting programs.